# Defense Technical Information Center Compilation Part Notice

# ADP014947

TITLE: Comparison of Experimental Measurements and Theoretical Description for Cathode-Directed Streamer

DISTRIBUTION: Approved for public release, distribution unlimited

## This paper is part of the following report:

TITLE: International Conference on Phenomena in Ionized Gases [26th] Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

To order the complete compilation report, use: ADA421147

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP014936 thru ADP015049

# Comparison of Experimental Measurements and Theoretical Description for Cathode-Directed Streamer

S Pancheshnyi, M Nudnova, D Opaits, A Starikovskii
Moscow Institute of Physics and Technology, Dolgoprudnyi, Russia, e-mail:pon@neq.mipt.ru

*At this work complex study of positive streamer development in $N_2/O_2$ mixtures at pressure range 0.1–2.0 atm has been performed. Experimental measurements of streamer discharge dynamics have been compared with direct numerical simulation within the scope of 2D hydrodynamics approach. Self-consistent analytical model that allows with the use of known potential of the high-voltage electrode to obtain associated values of the streamer parameters was developed and verified.*

## 1. Experimental Setup

Discharge section comprises cube chamber 20x20x20 cm. There is a possibility to pump up to $10^{-2}$ torr and to heat the chamber. Special optical windows are made of quartz to register optical emission in a wavelength range of 190-600 nm. A rotating-interrupter generator was used as a pulsed voltage supply. The high-voltage pulses were fed through a coaxial electric cable to the high-voltage connector of the discharge system. Repetitive frequency of the high-voltage pulses was 1.2 kHz, voltage amplitude in the cable was 15 kV, high voltage pulse on the half-height was 50 ns. A calibrated back-current shunt placed in the break of the shield of the feeding coaxial cable was used to control electrical parameters of the pulses. The emission spectroscopy technique was used to analyze a cathode-directed streamer discharge. The densities of excited molecules were determined and the reduced electric field in the streamer head was estimated [1].

## 2. Direct Numerical Simulation in 2D Geometry

Streamer discharge modeling was performed for pure $N_2$ and it mixtures with $O_2$ at different pressures at positive voltage up to 100 kV and interelectrode distance up to 20 cm. The modeling was performed in the hydrodynamic approximation for 2D geometry [2]. Numerical model considered balance equations for charged particles:

$$
\begin{aligned}
\frac{\partial n_e}{\partial t} + \mathrm{div}\,(\vec{v}_e \cdot n_e) &= S_{ion} + S_{photo} - S_{rec} \\
&\quad - S_{att} + S_{det} \\
\frac{\partial n_p}{\partial t} &= S_{ion} + S_{photo} - S_{rec} \\
\frac{\partial n_n}{\partial t} &= S_{att} - S_{det}
\end{aligned}
$$

Here $n_e$, $n_p$ and $n_n$ – densities of electrons, positively and negatively charged ions, $\vec{v_e}$ – drift velocity in a local electric field $\vec{E}$, $S_{ion}$, $S_{photo}$, $S_{rec}$, $S_{att}$ and $S_{det}$ – rates of ionization, photoionization, electron-ion recombination and electron attachment/detachment respectively. Electric field distribution $\vec{E}$ in the gap was calculated by Poison's equation:

$$
\begin{aligned}
\vec{E} &= -\nabla\varphi \\
\Delta\varphi &= -\frac{e}{\varepsilon_0}(n_p - n_e - n_n)
\end{aligned}
$$

## 3. Analytical Description

In [2] on the base of theoretical investigation and numerical modeling of streamer discharge in 2D geometry an analytical model of the cathode directed streamer head was proposed. The model allows us, with the use of known streamer head potential, to obtain values of the head radius and peak electric field in the head. According to the model, electron flux into the streamer channel is to be compensated by a flow of intensively multiplying electrons from the pre-ionization region in front of the streamer head.

## 4. Acknowledgments

This work was partially supported under grants 02-03-33376, 01-02-17785 of Russian Foundation for Basic Research, Project No 1474 of International Science and Technology Center and by Award No. MO-011-0 of the U.S. Civilian Research & Development Foundation.

[1] S.V. Pancheshnyi, S.V. Sobakin, S.M. Starikovskaya, A.Yu. Starikovskii *Discharge Dynamics and the Production of Active Particles in a Cathode-Directed Streamer* // Plasma Physics Reports **26** (2000) 1054.

[2] S.V. Pancheshnyi, S.M. Starikovskaia, A.Yu.Starikovskii *Role of Photoionization Prosesses in Propagation of Cathode-Directed Streamer* // Journal Physics D: Applied Physics **34** (2001) 105.